

Contributions to the Theory of Warning Colours and Mimicry, No. II.
Experiments with a Lizard (Calotes versicolor).—By FRANK FINN,
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[Read March 1896.]

Although I have made experiments with other species of birds besides the Babbler used for the experiments detailed in my paper in the *J. A. S. B.*, XLIV, p. 344, I prefer to record in the second place my experiences with the common Garden Lizard of India (*Calotes versicolor*), as being more complete. That this lizard eats butterflies there is no doubt; its semi-arboreal habits lead it to meet with them, and I have had specimens of these insects whose wings exhibited semi-circular notches which could only have resulted from the unsuccessful attack of one of these reptiles. I have observed such injuries in the case of *Catopsilia* and of both sexes of *Elymnias cendularis*. Moreover, I found lepidopterous remains in the stomach of an individual captured in the evening on a *Lantana* bush which was a great resort of butterflies.

These lizards are not such satisfactory subjects for experiment as birds, owing to their extreme deliberation in catching and eating their prey. As with the Babblers, I have with *Calotes* been able to check my experiments made on specimens in captivity, with other experiments made on specimens at large; but in the present case I do not know that any of the animals were identical, though some of my first captives, as stated below, were released in the Museum compound.

Dr. Alcock very kindly allowed me the use of a large cage of wire gauze placed in my office in which to confine the subjects of my first experiments: four specimens of *Calotes*, three of them fine, and the fourth of fair size. For three or four days after I got these, I gave them no butterflies, but threw in a plentiful supply of the maggots (those of a Muscid fly) usually employed here for feeding insectivorous birds. These turned in due course into flies, and when the lizards appeared to be eating these, and also some cockroaches (*Periplaneta americana*), I commenced the experiments given below, in regard to which I have to acknowledge Mr. Barlow's assistance in making observations.

Calotes versicolor

EXPERIMENTS WITH LIZARDS IN CONFINEMENT. SERIES A.

May 14th.—Put in four *Danaïs chrysippus*, and six non-warningly-coloured butterflies, mostly *Junonias*. After a time, I found three of the latter dead, apparently from natural causes. One *D. chrysippus* was on the floor with one wing gone, evidently mauled. Another *chrysippus* was alive and minus the tip of one forewing; nothing else was to be seen. There were flies about, and one lizard at least was eating

them. I found two *D. chrysippus* wings on the floor, and took out the dead plain-coloured specimens and the mutilated *D. chrysippus*, leaving the other still alive.

May 15th.—A few flies were still about. The *D. chrysippus* left overnight was dead but uneaten, though its head seemed to have been chewed.

I put in one *Junonia* and one *Euploea*, and one each of *Danais genutia* and *chrysippus*. Plenty of flies were soon to be seen, yet at the end of the afternoon all the butterflies seemed to have been eaten. In the evening, I put in one each of *Danais limniace*, *genutia*, and *chrysippus*, and seven non-warningly-coloured specimens. Before leaving, I saw a lizard with the *D. limniace* in its mouth.

May 16th.—Found a *Junonia* (dead) and a *Catopsilia* (alive) floating in the water-pan; two other plain-coloured specimens on the ground, dead, apparently from natural causes; one *D. chrysippus*, living, but minus much of its forewings, and many flies, nothing else. At the end of this day the *Catopsilia* was dead, apparently naturally, and the *D. chrysippus* had disappeared, though there were flies about. I then put in four male *Elymnias undularis*, one *Papilio aristolochiae*, and one *Euploea*.

May 17th.—To-day I found three *Elymnias* and the *Euploea* unhurt, but only two wings of the *Papilio aristolochiae*, which Mr. Barlow had seen a lizard trying to catch; there were flies to be seen. Before long I noticed an *Elymnias* notched; later two of these disappeared. I found the dead *Catopsilia* apparently eaten; possibly others had been also. I put in one *D. limniace* and two non-warningly-coloured specimens.

May 18th.—The *Euploea* remained alive and untouched all day. I found the *Elymnias* recently dead, with antennae gone and wings notched. The others had disappeared. There were flies in the cage. A large cockroach was soon mostly eaten. I put in some fresh maggots.

May 20th.—The *Euploea*, dead naturally, untouched, as also the dry body of the *Elymnias*. Some dead plain coloured specimens have been untouched all the time.

May 21st.—There were hardly any flies in the cage and I gave the lizards two large grey ones. In the evening I put in one each of *Danais genutia* and *limniace*, and *Euploea*, two *Catopsilia*, and one *Junonia* (this last dead). Soon a *Catopsilia*, going very close to a lizard, was snapped at, without hurry, but escaped by the tearing of its wing, to be soon eaten by another lizard which got a hold on its body.

A very large silkworm moth was in the cage most of the day, but not attacked. Mr. Barlow saw a lizard approach, but stop at some distance, apparently frightened.

May 22nd.—No butterflies left to-day but dead *Junonia*. No flies. The wings of the moth were torn, and later only the wings were found, so that some lizard had at last eaten it. I put in a headless cockroach, which was soon attacked, but the lizard apparently got pricked in the mouth, and the insect was not eaten. I put in in the evening two *Catopsilias*, two *Papilio eurypylus*, one *Euploea*, one *Danais genutia*, and a few small dragonflies. Almost immediately a *Catopsilia* was seized, but relinquished by a lizard. I saw another lizard with the *Euploea* in its mouth, which it ate. Shortly after I found a wing of one *Papilio*. A Mynah's egg untouched all day.

May 23rd.—Every butterfly gone but a *Catopsilia*, which was recently dead and un mutilated though the wings were somewhat torn, it appeared to have died naturally, it was the same specimen which I had seen taken and left yesterday. No flies were in the cage, and the cockroach left yesterday was not eaten. I took out the *Catopsilia*.

EXPERIMENTS WITH LIZARDS IN CONFINEMENT. SERIES B.

I now liberated three of the lizards, reserving only the finest. I put in two large black and yellow dragonflies in the evening.

May 27th.—These dragonflies were uneaten, though the lizard had apparently had no food since the 22nd. I saw about this time some other small dragonflies, apparently those put in before. I put in a large protectively-coloured moth, which before long disappeared.

May 28th.—The lizard, which now seemed to be very hungry, ate three or four cockroaches when put in, before Mr. Barlow's eyes, but left more still uneaten by the evening. I then put in one each of *Danais limniace*, *D. genutia*, *D. chrysippus*, *Euploea*, and *Catopsilia*, and a large brown species. I soon saw the lizard swallowing the *D. chrysippus*, none of the others having been attacked as yet. I then put in a large protectively-coloured moth, much like the Yellow-underwing.

May 29th.—In the morning *D. limniace* was alive and unhurt, but none of the other insects put in were to be seen but one cockroach.

Three hours later, *D. limniace* being still untouched, I put in a large grey fly, which the lizard immediately ate, as it did another put in some little time after. Not long after I put in a third, and the lizard rushed past the *D. limniace* and eagerly took it.

A small gecko put in was not attacked: soon afterwards the *D. limniace* was gone, some of its wings being left, and the cockroach still there, and I put in a *Papilio eurypylus*, which was uneaten when I left.

May 30th.—The *Papilio* was gone this morning, but the gecko and some cockroaches were still there.

Ceased experimenting with this lizard, which I killed to feed some birds.

A month afterwards I commenced experimenting with lizards in their natural state in the Museum compound, the butterflies being usually disabled by having the anterior nervure of the fore-wings broken. Owing to the above-mentioned deliberation of the lizards' movements, the work of watching them was very tedious, and I did not always see the final result. I commenced experiments by offering a cockroach, as stated below.

EXPERIMENTS ON LIZARDS AT LIBERTY.

July 7th.—Gave a decapitated cockroach to a big lizard in the compound. The lizard rushed to the insect, and after a little hesitation, apparently on account of the kicking legs, seized and carried it off; I did not see what then happened, as the lizard on my approach went up a shrub.

July 9th.—A *Papilio demoleus* and a *Danais genutia* offered to a lizard, were not attacked. I therefore offered them to another. The *Danais* disappeared when I was not looking, but it might have fluttered away. I took away the other.

July 10th.—Offered a *Danais chrysippus* to lizards. One attacked and let it go (or lost hold) once or twice; then this lizard was attacked by a bigger one and a scuffle ensued, and the lizards ran off fighting and left the butterfly, which did not seem hurt, and was not eventually taken, though I let it remain for a little.

July 12th.—In the morning, put a plain-coloured species (*Junonia* I think) and a *Danais chrysippus* near a large *Calotes*. The lizard took the former, which was nearest, and went off with it.

I then offered a *D. genutia* to another *Calotes*, which took and ate it.

I gave another *D. genutia* to a smaller specimen of this lizard, which seized it and ran off with it in its mouth as after a little time I approached.

I then offered an *Euploea* to another large lizard. After a little time he attacked it, but it got away, and he pursued it; then another smaller lizard appeared and possibly there was a fight. If the butterfly was taken, this was done quickly, for I could not find it, nor did I see it in the possession of the lizards.

I then offered a *D. limniace* to the first of these two lizards, but it did not offer to touch it. I put the same insect not far from a smaller lizard, which bit off a piece of wing, and then after a little while went away. I put the same specimen near another, which appeared to see it, and yet ran past, possibly attracted by a fight between lizards further on.

July 15th.—Offered in the evening a *Danais genutia* to a large lizard, which ultimately took and ate it with much chewing.

July 16th.—Put one specimen each of *Danais genutia* and *D. limniace* near a lizard, which did not seem inclined to attack them. I therefore put them before another, which, after a while, passing close to the *D. limniace* which was lying still nearest to him, seized the *D. genutia*, and when approached went off with the insect in its mouth.

The *D. limniace* was dead, killed by ants when first put out, I think. In the evening I put an *Euploea* near a big *Calotes*, I believe the same to which I had offered this butterfly before (July 12th), but though I left it there for some time, it was not taken.

July 17th.—Offered an *Euploea* to a fat and sickly-looking lizard, probably heavy with eggs. The insect was not touched, though left near for some time.

I put the butterfly not far from another lizard, and not long after saw a lizard (apparently not the same individual) with it in its mouth. The lizard ran off with its prey. Exposed a *Euploea* on a tree trunk for some time within a few inches of a big lizard. Ultimately it disappeared, and the lizard appeared to have moved further up.

July 18th.—In the evening put an *Euploea* and a *Catopsilia* on rough ground near a fair-sized lizard, the *Catopsilia* being a little the further off. The lizard stalked, seized, and ate the *Euploea*. A bigger lizard, which had watched the proceeding with apparent interest, then took and ate the *Catopsilia*, more quickly than the other had done the *Euploea*, no doubt because this butterfly was smaller. He did not attack at once, though apparently in no fear of the other.

Exposed specimens of *Danais genutia* and a plain-coloured species to two lizards, but failed to attract them; they were probably afraid of me.

July 24th.—Offered a non-warningly-coloured species to a large *Calotes* near the tank, with a *Danais genutia* placed nearer the lizard. After a time the lizard took and ate the *Danais* before my eyes. Put a *D. genutia* and a non-warningly-coloured specimen near a lizard on a tree. I waited some time, but neither was touched; the lizards had been a little frightened.

Threw a *D. genutia* almost under the nose of a big *Calotes* on the tree, but though I waited some time, he did not catch it, but moved off towards another lizard.

July 27th.—Put specimens of *Danais limniace* and *Papilio demoleus* not far from a lizard (near the tank). He did not attack, but after a time I found only the wing of the *D. limniace*, and another lizard ran off, which might have taken it.

July 28th.—Put out a large *Catopsilia* and a *Danaïs limniace* near the lizards' tree by the tank. Some while afterwards the *Catopsilia* was gone; but it might have got away, as breaking the costal nerve does not disable these as it does Danaïds. The *Danaïs* was still there.

Later in the day I put this *Danaïs* near another lizard, before very long the lizard stalked and seized it with a spring and slowly ate it before me.

July 30th.—Offered in the morning a *Papilio aristolochiae* to a big *Calotes* near the tank. In a little while I saw him with it in his mouth, and he then ran off with it. I offered another *P. aristolochiae* to another large lizard. He stalked it almost immediately, seized it after a pause, chewed it slowly, and had got all down but part of one fore-wing when he disappeared, no doubt frightened. Later on I exposed a *Catopsilia* on the tree by the tank; it was on a leaf not far from a lizard, and this soon had it in its mouth and ate it.

August 1st.—Exposed a *Papilio demoleus* to a *Calotes* in the Art School compound; the insect weak but not disabled, fell at a little distance; then I disabled a fine *Papilio aristolochiae* and threw it to the lizard. It fell very near and was immediately seized and slowly eaten, all but parts of two wings and a leg, knocked off at the last. Meanwhile the *P. demoleus* was fluttering about, and the lizard must have seen it. I then took it away.

August 2nd.—I offered to a *Calotes* in the Art School compound a *Papilio eurypylus* and *P. aristolochiae*. He soon attacked, paused and went on over *P. eurypylus* which was nearest, seized *P. aristolochiae*, and ate it all but part of the forewings a hindwing and the abdomen, which I found afterwards. As the abdomen was not chewed, and had the unchewed wing attached to it, I supposed the lizard had chewed it off unwittingly.

This lizard did not seem inclined to eat *P. eurypylus* afterwards, but another to which I threw the insect soon seized it by the wing and began to chew this; and as I soon missed both, no doubt retired with its prey.

I do not know if the first lizard was the same as yesterday's; it was about the same place.

November 2nd.—In the morning I exposed to a lizard a *Delias eucharis* which was almost immediately seized, and the lizard began apparently to chew it, when a movement of mine startled it, as it remained still, holding the insect in its mouth (a common habit) and it ran off with its prey.

November 10th.—Exposed a red-eyed skipper (*Matapa aria*) near a large *Calotes*, which after a little seized and ate it.

Since this date I have seen a small *Calotes* seize and eat a small conspicuous orange-red insect, apparently a "lady-bird."

The behaviour of these reptiles certainly does not appear to afford support to the belief that the *butterflies*, at any rate, usually considered nauseous, are distasteful to them.

A Note on the Nature of the Substance formed during fermentation, from which Indigo Blue is eventually formed in Indigo Manufacture; and on Indigo Brown.—By SURG.-LT.-COL. G. S. A. RANKING, B.A., M.D., M.R.A.S.

[Read March, 1896.]

Indigo liquor when properly fermented is a greenish yellow infusion having a very marked greenish fluorescence. In reaction it varies, though the reaction is faintly alkaline when the liquor is most favourably fermented. A distinctly acid reaction always indicates unfavourable fermentation, and results in loss of produce of Indigo-blue.

It contains a substance in solution which forms a yellow solution with alkalis, and from this yellow solution Indigo-blue may be very readily obtained by simple agitation with air.

Now the nature of this Indigo-forming substance has been hitherto undecided. That it very closely resembles Indigo-white cannot be denied, as will be seen from a comparison of the reactions of Vat-liquor and solutions of Indigo-white respectively with metallic salts, herein-after set out in tabular form. (*See Table page 51.*)

But there are certain difficulties in the way of any theory which would declare them to be identically the same, of which one is this, that Indigo-white is well known to be insoluble except in alkalis, whereas it is certain that in acid Vat-liquor the Indigo-forming body is present in solution.

For many years I held the opinion that the substance present in the Vat-liquor after fermentation is so nearly allied to Indigo-white as to be practically identical with that body, and I considered that it might be an isomer of Indigo-white, which differed from that body by being soluble in acids, as well as in alkalis; I have, however, as a result of further research, come to the conclusion that the body present differs from Indigo-white in composition, though in its reactions with metallic salts it is apparently identical, and I have been led to conclude that it is probably Indoxyl (C_8H_7NO) a body containing one more atom of Hydrogen than does Indigo-white.